

said by him to be "situated on each side of the middle part of the animal, and generally coloured yellow or red (primitive kidneys?)" (*Ann. & Mag. Nat. Hist. Nov.* 1874, p. 383).

I may add that all these observations were made on living *Limulus polyphemus*, in the laboratory of the Anderson School of Natural History, at Penikese Island, Mass.

XXXIV.—*On some Fossil Fishes from the Neighbourhood of Edinburgh.* By R. H. TRAQUAIR, M.D., F.G.S., Keeper of the Natural-History Collections in the Edinburgh Museum of Science and Art*.

[Plate XVI.]

I. *Nematoptychius Greenockii*, Agass., sp.

EIGHT years ago I published a paper † giving a detailed description of a fish from the Wardie Shales, which I considered, and still do so, to be the *Pygopterus Greenockii* of Agassiz. Since that time remains of the same fish have turned up in many other localities near Edinburgh, showing that it enjoyed a range extending upwards into the true Coal-measures. Proceeding upwards from the Wardie Shales, it occurs in the horizon of the Burdiehouse Limestone, a specimen in the British Museum (no. 45867) from Burntisland, in Fifeshire, displaying numerous scales and bones of this species, commingled with similar relics of *Eurynotus crenatus*. Numerous specimens also in the Edinburgh Museum of Science and Art, and in private collections, show its not uncommon presence in the "Edge-Coal" strata of Gilmerton and Loanhead, and in the Upper Coal-measures of Shawfair. With the exception of a head, with the anterior part of the body, from Gilmerton, belonging to Mr. Somervail of Edinburgh, and an entire though badly preserved specimen from Woolmet, near Edmonston, in the Museum of Science and Art, all the specimens as yet procured from beds above the Wardie Shales are very fragmentary; yet some of the fragments, from the softer nature of their matrix, afford us some details regarding the

* Communicated by the Author, having been read before the Geological Society of Edinburgh, 4th February, 1875.

† "Description of *Pygopterus Greenockii*, Agass., with Notes on the Structural Relations of the Genera *Pygopterus*, *Amblypterus*, and *Eurynotus*," *Trans. Royal Soc. Edinb.* vol. xxiv. 1867, pp. 701-713, pl. xlv.

teeth and scales, which it is difficult to obtain from those preserved in the refractory ironstone of the Wardie nodules.

In his very brief notice of this fish* Agassiz stated that, though very distinct as a species, its generic relations were doubtful, mentioning as a reason that the scales were much higher than broad. Having, since my previous description was written, enjoyed better opportunities of studying the characters of the genus *Pygopterus*, I have found the conclusion inevitable, that Agassiz's doubts were so well founded that it becomes absolutely necessary to erect a new genus for the fish under consideration. I propose, then, for it the generic title of *Nematoptychius*, in allusion to the fine thread-like striae with which the scales and many of the head-bones are ornamented.

As regards the scales, these differ in a most marked manner from those of *Pygopterus*. In the latter genus they are regularly rhomboidal (Pl. XVI. fig. 6); and over the greater part of the body they are equilateral, those in the front of the flank only being rather higher than broad. The exposed rhombic surface has its acute angles pointing, as usual, upwards and forwards, downwards and backwards; the anterior-superior angle is produced into a prominent point covered by the adjoining scale; while from the middle of the upper margin a special and well-marked articular peg or spine likewise rises, to be received into a corresponding depression on the under surface of the scale above. In fact Agassiz describes the scales of *P. mandibularis* as being very firmly articulated by means of "deux cornes, qui existent au bord supérieur de l'écaille, et se logent sous la surface émaillée de l'écaille voisine" †. These "deux cornes" (the one a production of the anterior-superior angle of the scale, the other a special articular spine arising from its upper margin) are indeed, as every one knows, by no means specially characteristic of *Pygopterus*. In *Nematoptychius Greenockii*, however, the scale is of a very different and, in truth, most peculiar form (Pl. XVI. figs. 9, 10, 11). All along the back and flanks the scales are much higher than broad; the exposed area is indeed more or less rhomboidal; but the acute angles are here the posterior-superior and the anterior-inferior. The anterior-superior angle is not produced into an articular point, distinct from the proper articular spine, which latter, broad and triangular, arises from the entire upper margin of the scale. The exposed ganoid surface is ornamented by very delicate thread-like, wavy, branching and anastomosing ridges, which, in the

* Poissons Fossiles, t. ii. pt. 2, p. 78.

† *Ibid.* p. 76.

scales of the flank, are subparallel and run more or less vertically down the scale, or between the two acute angles (fig. 9); on the scales of the back, however, they often follow a more irregular and flexuously contorted course (fig. 11).

The general contour of the fish, too, as shown in the figure illustrating my previous paper, differs considerably from that in *Pygopterus*. In such typical *Pygopteri* as *P. mandibularis* or *P. Humboldtii*, both dorsal and anal fins are placed much in front of the caudal; the dorsal is not particularly large for the size of the fish (in fact none of the fins are, save the caudal, which is truly tremendous); but the base of the anal is peculiarly extended backwards. On this latter peculiarity Agassiz dwells particularly in characterizing the genus; for he says, "mais ce qui caractérise plus particulièrement les *Pygopterus*, c'est qu'à cette caudale inéquilobe se joint une anale fort longue qui garnit le bord inférieur du corps sur une grande étendue"*.

In *Nematoptychius Greenockii*, on the other hand, the dorsal and anal are considerably larger in proportion, and placed nearer the tail, and the anal fin may be said to be the exact counterpart of the nearly oppositely placed dorsal. Other fishes have indeed been named "*Pygopterus*," in which the peculiar character of the anal fin referred to is also absent, as, for example, in the very imperfectly known *P. Bucklandi* of the Burdighouse Limestone, of which Agassiz says that it is characterized by having its anal "très-rapprochée de la caudale"†. Whatever value, however, we may be inclined to place on the form and position of these fins in a more extended revision of the genus *Pygopterus*, the form of the scales alone is certainly abundantly sufficient to distinguish *Nematoptychius* generically, not only from *Pygopterus*, but from all the other known genera of the family of Palæoniscidæ.

In my former communication the *teeth* were imperfectly described, it being very difficult to obtain satisfactory views of them in the Wardie specimens, owing to the hardness and peculiar nature of the ironstone in which they are enclosed. Specimens from Loanhead, however, preserved in soft bituminous shale or in cannel coal, afford better opportunities for studying their configuration (Pl. XVI. fig. 8). They are acutely conical, round in transverse section, and more or less curved inwards. Their apices very distinctly display the well-known "enamel cap" clearly marked off on the exterior of the

* Poissons Fossiles, t. ii. pt. 2, p. 74.

† *Ib.* p. 77. I cannot refrain from expressing very considerable doubts as to that species, or, in fact, any other of the so-called Carboniferous "*Pygopteri*," being really referable to that genus.

tooth, so as to present an appearance almost as if a little extinguisher had been stuck on to the point. Below this, which is quite smooth, the polished surface is ornamented with fine striæ, more marked in some specimens than in others, and which consist, in fact, of very delicate linear depressions, often interrupted and wavy. These are best marked just below the enamel cap, and become lost towards the base of the tooth, which is dull and smooth. Microscopically the teeth display a structure quite similar to that described by Agassiz in *Pygopterus*, and by Messrs. Hancock and Atthey in *Palæoniscus Egertoni*. The pulp-cavity is simple and wide at the base, becoming attenuated upwards into the body of the tooth; the dentine displays the same arrangement of radiating tubules, and is crowned above by a cap of structureless "enamel," which also sends down a very thin and delicate layer over the whole external surface. I formerly described the teeth as quite smooth; and so they seemed to be in the specimen then at my disposal. The apparent absence of the striæ in these Wardie specimens, however, is evidently due to flaking-off of the external enamel film above mentioned, the surface being at the same time left rather dull; and I have since seen specimens from that locality in which the external polished surface still remains, and which show the very same striæ as those seen in specimens from other localities, preserved in a softer matrix.

The maxillary bone, represented in Pl. XVI. fig. 7, is from Shawfair, and, though undoubtedly belonging to the same species, is proportionally shorter and broader than is usually the case. I have another from Loanhead, which shows the same peculiarity. Neither of these belonged to full-grown fish, in which the maxillary often attains a length of $2\frac{3}{4}$ inches by 1 inch in breadth posteriorly. The teeth are of different sizes; the larger ones, measuring in ordinary specimens from $\frac{1}{2}$ to $\frac{3}{4}$ inch in length, are arranged in a row at somewhat irregular intervals; and occupying a more external position on the edge of the jaw is a line of smaller teeth, whose length varies from about $\frac{1}{16}$ to $\frac{1}{8}$ inch. Certain specimens from Shawfair and Woolmet appear to have undergone much pressure, the bones and scales being very thin, though retaining their markings as distinctly as ever, and the teeth being considerably flattened, especially at their bases, as might have been expected. In these instances, however, the enamel cap remains unaffected, standing out all the more distinctly, while the striæ on the body of the tooth are also more strongly marked. These appearances are, I think, certainly due to changes occurring during fossilization, and not to specific difference.

The principal characters of the genus may be summed up as below :—

NEMATOPTYCHIUS, Traq., = *Pygopterus*, Ag., partim.

Body slender; head large, with bluntly pointed projecting muzzle; orbit far forward; gape very wide, with powerfully developed jaws; operculum rather small. Dentition powerfully developed; teeth of two principal sizes, acutely conical, and enamel-tipped. Pectoral and ventral fins moderate; rays of the pectoral articulated; dorsal and anal fins nearly equal, large, triangular; dorsal situated nearly opposite the anal; tail completely heterocercal; fin-fulcra small. Scales very peculiar in form; those of the flanks much higher than long, with a flat triangular articular process arising from the whole, or nearly the whole, upper margin; anterior-superior and posterior-inferior angles of the exposed face of the scale obtuse; ornament consisting of fine closely set thread-like ridges.

Nematoptychius Greenockii, Ag., sp.—The only species of the genus, and as yet only obtained from the Scottish Carboniferous strata.

For further details as to the general configuration and structure of this fish, including the osteology of the head, I must refer the reader to my previously quoted memoir in the 'Transactions of the Royal Society of Edinburgh.'

II. *Wardieichthys cyclosoma*, gen. et sp. nov.

This little fish, in my own collection, is contained in a nodule of clay ironstone from the shales at Wardie, and was found on the beach there, about fifteen years ago. It is entire, with the exception of the tail, which is unfortunately wanting. The body, including the head, measures 3 inches in length by $2\frac{1}{4}$ at its greatest depth, and is remarkable for its nearly circular outline, and especially for the highly arched contour of the back, the ventral margin being much less curved. Fig. 1, Pl. XVI., represents the "counterpart" or impression of the specimen, which, however, will convey a better idea of the form of the fish than the other half of the nodule, as from the latter a little bit of the back unfortunately splintered off and was lost in the act of splitting it open.

The head equals about $\frac{1}{3}$ the total length, without the tail; it is a little crushed over towards the right side, and a good deal of displacement seems to have taken place with the facial bones, only a few of which are recognizable. The cranium proper is short, the snout blunt and rounded as in *Mesolepis*; and the

orbit seems to have been well forward, as in the last-named genus. In Pl. XVI. fig. 2 I have indicated in diagrammatic outline the various bones which may be distinctly made out. Behind we have a pair of *parietals* (*p*), in front of which are the more elongated *frontals*, of which the impression of the right one (*f*) is seen; on the outer side of the parietal is a plate (*sq*), which answers to the *squamosal*, in front of which, and external to the frontal, is another (*p.f*) which may be reckoned as the *post-frontal*. The bones of the ethmoidal region, forming the short rounded snout, are too much crushed for description. All these cranial bones, as shown by their impressions, were ornamented by beautiful branching and anastomosing flexuous ridges; the impressions of their internal surfaces, shown by removing the friable bone from the other half of the specimen, display lines radiating from the ossific centres; and here also a groove, traversing longitudinally the frontal and parietal, betrays the course of the usual slime-canal. Very little is seen of the facial bones. A portion of the *hyomandibular* (*h.m*) is seen passing downwards and slightly backwards from under the squamosal, and seems to have been a rather slender bone like that of *Palaeoniscus*. The *operculum* (*op*) is shaped much like that of *Mesolepis*, being four-sided, rather higher than broad, and with round posterior-superior and posterior-inferior angles; it is evidently displaced somewhat upwards and backwards. Below it is the *suboperculum* (*s.op*), also displaced and apparently a little turned round, so that what I conceive to be its upper margin comes in fact to look as much forwards as upwards. The only other recognizable facial bone is the *maxilla* (*mx*), a plate of considerable size, gently convex externally and broader behind than in front; its external surface was ornamented by wavy ridges very similar to those on the cranial bones. The lower jaw and branchiostegal rays are, unfortunately, not discoverable, nor have I been able to detect any trace of teeth.

Shoulder-girdle.—The *first supraclavicular* (*suprascapular*, Owen) is a very large, nearly square-shaped plate (*1st s.cl*), which is placed behind the parietal, and is apparently in contact at the middle line with its fellow of the opposite side. By its lower margin it articulates with the *second supraclavicular* (*scapular*, Owen), also of considerable size. This bone (*2nd s.cl*) is vertically oblong in form, rather broad above, where it is obliquely traversed by the lateral slime-canal before that tube enters the scales of the lateral line, and narrowing down to a point below. I exposed the whole of it by sacrificing and chiselling off the operculum (which covered a large part of it), as the whole contour of the last-mentioned bone is so well seen

in impression on the half of the nodule represented in fig. 1. In the diagrammatic outline, fig. 2, the second supraclavicular is seen largely covered by the somewhat displaced operculum. Both supraclaviculars agree very closely in form and position with the corresponding bones in *Mesolepis*, as seen by comparison with a very beautiful and perfect specimen of *M. scalaris*, Young, kindly lent me by my friend Mr. Ward. Some traces of an elongated clavicle are also seen, but not sufficiently marked for description.

Fins.—The specimen shows no trace of either pectorals or ventrals. The *dorsal* fin is small, and commences considerably behind the centre of the arch of the back; it is composed of numerous closely set rays, divided by very frequent transverse articulations. The most anterior rays are very short, but they increase rapidly in length to the ninth or tenth, from which the margin of the fin again falls away, so that it becomes more fringe-like posteriorly, where the rays are seen also repeatedly to bifurcate. Traces of fine fulera are seen on the anterior margin. On the opposite aspect of the body some remains of the anal fin are seen—unfortunately only a few broken rays; yet from these we may pretty safely conclude that it corresponded in size and position to the dorsal.

Scales.—The scales of the side of the body are high and narrow, diminishing very regularly in size from before backwards. Their form is rhomboidal, the acute angles being the posterior-superior and the anterior-inferior. The external surface of each presents a well-defined, smooth anterior margin, produced downwards into the lower acute angle or point of the scale, overlapped by the scale in front, and corresponding to the thickened articular rib on the internal aspect. The latter is by no means strongly marked: it passes above into a pointed articular spine of moderate size; and below, it is obliquely bevelled off behind for the articular depression which receives the corresponding peg of the scale next below. The exposed surface is ornamented by a beautiful granular tuberculation, the little tubercles sometimes being arranged in lines or coalescing into short ridges, whose direction is always more or less *across* the scale, some tendency to radiation downwards towards the posterior-inferior angle being also often observed towards the lower part. This tendency of the tubercles to coalesce into transverse ridges is most pronounced in those scales which are situated more posteriorly (Pl. XVI. fig. 3), though I observe it also in one placed just behind the lower part of the suboperculum. The two scales represented in fig. 3 are from the lateral line, a little in front of the origin of the dorsal fin; they are seen to be each marked with

a slight notch on the posterior margin, and are evidently obliquely perforated by the lateral slime-canal.

Towards the dorsal and ventral margins the scales get considerably lower than on the flanks. Those represented in fig. 5 (also magnified two diameters) are from a situation further to the front of the fish than those from which fig. 3 was taken—namely, from the belly, a little distance behind and below the suboperculum. In them the articular spine is very broad and triangular, arising from the entire upper margin of the scale, and showing besides a few peculiar grooves on the surface, radiating from the middle of the base.

The foregoing description of the configuration of the scales has, together with the illustrative drawings, been principally taken from impressions left on the hard ironstone after very careful removal of the friable osseous matter, and from accurate “squeezes” in modelling-wax taken from the same.

Conclusion.—From the foregoing description it is at once evident that the little fish just described belongs to the Palæozoic section of Dr. Young’s suborder of *Lepidopleuridæ*; but it can hardly be included in any previously described genus. Necessarily leaving dentition out of consideration, the shape of the body and the relations of the dorsal fin alone widely distinguish it from *Mesolepis* and *Amphicentrum*. From *Platysomus* it is also separated by the form of the head, with its short blunt snout and relatively more anteriorly placed orbit, as well as by the nature of the scale-ornament, which in all the described species of *Platysomus* consists of fine vertical or slightly diagonal ridges or striæ. In the typical *Platysomi* too (*e. g.* *Pl. gibbosus, striatus*) “the dorsal fin commences at the *culminating point* of the dorsal ridge, and extends thence to the upper lobe of the caudal fin, the component rays diminishing very gradually in length from first to last;” moreover it contains “from 80 to 100 fin-rays”*; here, on the other hand, the dorsal fin commences very much behind the highest point of the back and contains considerably fewer rays, though their exact number is not ascertainable. There only remains the very imperfectly known genus *Cleithrolepis*, Egerton†, from beds of doubtful Carboniferous age in New South Wales, and which, to certain points of resemblance to *Platysomus*, adds the peculiarity of having a homocercal tail; this organ, being absent in our specimen, is not available as a means of comparison. Although the rounded figure and posteriorly arising dorsal fin of *Cleithrolepis*, added to Sir Philip Egerton’s state-

* Sir Philip Egerton, in ‘Quart. Journ. Geol. Soc. London,’ 1864, xx. p. 3.

† *Loc. cit.* p. 3, and pl. i. figs. 2 & 3.

ment that the scales are granulated, do remind us of the fish under consideration, yet so little is known of the structural details of the Australian fish, that all evidence of generic identity is wanting. As far as Sir Philip Egerton's description and figures go, however, the head of *Cleithrolepis* would seem to have been much smaller in proportion, the vertical rows of scales much more numerous, and the articulating rib on the anterior margin of the inner surface of each scale very considerably stronger. On the whole, I think it is better to bestow a new generic title on the present fish; and accordingly I propose for it the name *Wardichthys**, coupled with the specific designation *cyclosoma*.

WARDICHTHYS, gen. et sp. nov., Traquair.

Body flat, nearly circular, back very highly arched; dorsal and anal fins small, opposite, the former arising much behind the culminating point of the rounded dorsal arch and extending to the tail-pedicle. Pectoral, ventral, and caudal fins unknown, the latter probably heterocercal. Scales ornamented externally with fine tubercles, which often coalesce into short transverse ridges; lepidopleura weak. Snout short, rounded; orbit well forward; cranial bones ornamented by fine flexuous ridges or striæ.

Wardichthys cyclosoma.—The only known species; and of it, as yet, only one specimen has been obtained, from the Lower Carboniferous shales of Wardie (Newhaven), on the Frith of Forth, near Edinburgh.

III. *Rhizodus Hibberti*, Agass., sp.

A specimen of *Rhizodus Hibberti*, Agass., sp., from the blackband ironstone of Gilmerton, recently acquired by the Edinburgh Museum of Science and Art, throws some additional light on the structure of this remarkable and gigantic fish, concerning which so little is yet known in spite of the comparative abundance of fragmentary remains. It is a fragment of what would apparently have been a most magnificent and truly unique specimen, had the whole of it been obtained; as it is, it shows a portion of the head, shoulder, and anterior part of the body of an example of moderate, or rather small size, for a *Rhizodus* at least. The entire

* In honour of Mr. J. Ward, of Longton, Staffordshire, to whom I am indebted for much valuable assistance in the study of Carboniferous fishes.

length of the fragment is 16 inches, and its greatest breadth 8 inches; in front there are some mutilated and unreadable remains of the head extending back for about 6 inches; but here a few doubly trenchant teeth of the well-known aspect and structure settle the question as to its being a *Rhizodus*. Behind these head-remains, and lying across the specimen, is a great part of a well-marked *clavicle*, resembling in shape that of *Holoptychius* and ornamented externally by reticulating ridges, furrows, and pits. The amount of it seen is $5\frac{1}{2}$ inches in length; it is overlapped in front by some portions of head-bone, probably opercular; above, it is broken off at the edge of the specimen; and below, its termination is not very distinct, though I am rather disposed to think that another portion of bone coming on here is the *interclavicular*. The posterior margin shows a shallow excavation, from which issues a *pectoral fin*, obtusely or "subacutely" lobate in shape. The "lobe" is 3 inches long by $1\frac{3}{4}$ broad; it is fringed with rays on the upper and posterior margins, some remains of them extending also a little round on the lower. The most perfect rays are those on the extremity of the lobe, where $1\frac{1}{2}$ inch of their length is seen; they are slender, smooth, and very closely set; for an inch of their length they are unarticulated, after which transverse divisions are evident.

Behind the remains of the head and pectoral arch the specimen is covered by scales, which agree perfectly with those which we have been accustomed to refer to *Rhizodus Hibberti*. They lie for the most part undisturbedly *in situ*, deeply imbricating over each other, but, as usual, are mostly so split that only their internal structure, not their external sculpture, can be seen. One of these scales, just behind the upper end of the clavicle and pushed rather out of place, is seen to measure $1\frac{1}{2}$ inch in length by $1\frac{1}{4}$ in breadth; on the pectoral lobe the scales are very much smaller.

It is much to be regretted that the above-described fragment is all that has been saved of a specimen which was probably entire before the miner invaded its ironstone bed. Nevertheless the discovery of the pectoral fin of *Rhizodus* is of great interest, inasmuch as it furnishes us with another most important point of deviation of its structure from that of the Devonian genus *Holoptychius*, with which it was so long and so obstinately confounded. In *Holoptychius* the pectoral, as shown by Prof. Huxley, is long and very acutely lobate, like that of *Glyptolepis*; the obtusely lobate corresponding fin of *Rhizodus* shows that it must be placed apart from these, in a distinct subdivision of the great Glyptodipterine family, along with its smaller congener *Rhizodopsis*.

EXPLANATION OF PLATE XVI.

- Fig. 1. *Wardichthys cyclosoma*, Traq.; impression of right side of the fish, natural size.
- Fig. 2. Diagrammatic outline of the recognizable bones of the head and shoulder: *p*, parietal; *f*, frontal; *sq*, squamosal; *p.f.*, post-frontal; *op*, operculum; *s.op.*, suboperculum; *mx*, maxillary; *h.m.*, hyomandibular; *1st s.cl.*, first supraclavicular; *2nd s.cl.*, second supraclavicular.
- Fig. 3. Scales from the lateral line situated a little in front of a perpendicular from the commencement of the dorsal fin, magnified two diameters.
- Fig. 4. Inner aspect of another flank-scale, magnified two diameters.
- Fig. 5. Several scales from near the ventral margin, a little distance below and behind the suboperculum, also magnified two diameters.
- Fig. 6. Inner surface of scale of *Pygopterus maulibularis*, Agass., magnified. After Sir P. G. Egerton, in King's 'Permian Fossils.'
- Fig. 7. Outline of a peculiarly short maxillary bone of *Nematoptychius Greenockii*, Agass., sp. The contour is seen in impression, all the actual bone that remains is along the dental margin.
- Fig. 8. Tooth of *Nematoptychius Greenockii*, seen from the outer side of the jaw, and magnified four diameters.
- Fig. 9. Flank-scale of the same fish, magnified three diameters.
- Fig. 10. Inner surface of a similar scale.
- Fig. 11. Ornament of a group of four scales from the back of another specimen, also enlarged three diameters.

XXXV.—*Descriptions of new Species of Fish in the Collection of the British Museum.* By A. HALY.

Hæmulon hians.

D. $\frac{12}{15}$. A. $\frac{3}{9}$. L. lat. 50. L. transv. $\frac{6}{12}$.

The height of the body equals the length of the head, and is contained three times and a half in the total. The snout is of moderate length, rather longer than the eye, which is contained three times and a half in the length of the head. The cleft of the mouth is very wide, the maxillary reaching to the vertical from the centre of the eye. Præoperculum with the posterior limb nearly vertical, obtusely denticulated, the denticulations somewhat stronger at the angle. Dorsal deeply notched; the fourth spine longest, nearly half the length of the head, the last spine longer than the eleventh. Caudal forked. Second anal spine stronger but scarcely longer than the third, as long as the sixth dorsal spine. Pectoral one fifth of the total length. The fish appears to have been longitudinally striped.

Two specimens in spirits from Bahia, and a young stuffed specimen from the same locality. The adults are $7\frac{1}{2}$ inches long.